Maxillary overdentures on dental implants
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Document Version
Publisher's PDF, also known as Version of record

Publication date:
2018

Link to publication in University of Groningen/UMCG research database

Citation for published version (APA):

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Does a large dehiscent implant surface at placement affect 5-years treatment outcome? An assessment of implants placed to support a maxillary overdenture

This chapter is an edited version of the manuscript:
Boven GC, Meijer HJA, Slot W, Vissink A, Raghoebas GM
Does a large dehiscent implant surface at placement affect the 5-year treatment outcome? An assessment of implants placed to support a maxillary overdenture.
Abstract

**Objective** The aim of this study was to assess the 5 years clinical and radiographic outcome of implants with a dehiscent surface at implant placement.

**Material and methods** A total of 26 consecutive patients (61.6±8.0 years) with at least one implant with a dehiscent implant surface of ≥ ⅔ of the implant length at the labial side were included. All implants were placed to support a maxillary overdenture. The implants were placed with adequate primary stability and the dehiscent surface was covered with autologous bone, anorganic bovine bone and a resorbable membrane. Outcome measures were soft tissue conditions, change of radiographic marginal bone level and implant survival. Baseline data (at loading, T0) were compared with 1 (T1) and 5 (T5) years post loading data.

**Results** Of the 116 implants, 40 implants had no dehiscences, 16 a buccal dehiscence <⅔ of the implant length and 60 implants a dehiscence ≥⅔. The peri-implant tissue was healthy and 5-years marginal bone loss was well within normal limits (0.4mm [-0.8 - -0.1]). One implant was lost during the osseointegration period.

**Conclusions** Placing implants with a dehiscence ≥⅔ of the buccal implant surface with good initial stability combined with covering of the dehiscent surface with autologous bone, anorganic bone and a resorbable membrane is accompanied by a favourable 5-years peri-implant health.
Introduction

Nowadays, a great variety of evaluations on performance of dental implants is done. Most evaluations employ inclusion criteria implying placement of implants in nearly ideal conditions, i.e., sufficient quantity and quality of bone and no infection at the implant site (1). With the dissemination of implant treatment and increasing patients’ demands, there is a growing pressure in implant dentistry to perform rehabilitations with implants placed in “non-ideal” conditions including placement of implants in fresh extraction sockets, periodontal compromised areas, and sites with low bone density and/or quantity. The latter condition is accompanied by an increase on presence of dehiscences or fenestrations at implant placement (2–4).

Evidence on how implants can be reliably inserted with large dehiscences of the implant surface at time of placement particularly with regard to the long term outcome is sparse. A finite element analysis showed that presence of buccal or lingual dehiscences is accompanied with an increase in marginal bone strain at the mesial and distal sites of the implant. This increased strain increases the risk of bone tissue overload at such locations (5). Deeper peri-implant pockets and greater clinical attachment loss have been reported for implants inserted in sites with dehiscences and guided bone regeneration than in healed sites without dehiscences (6). To prevent attachment loss related to dehiscences at the time of implant placement, a variety of membranes, autologous bone and bone substitutes has been used (7).

Even though placing implants without a complete coverage by bone at placement might be suboptimal, such approaches are commonly applied in routine clinical practice, also in the severely resorbed maxilla. As it is not well known how implants, used to retain a maxillary denture, that were placed with a dehiscence of the implant surface perform on the long run. The aim of the present study was to assess the clinical and radiographic outcome of such implants that have been in function for five years.

Materials and methods

Patient selection

A total of 26 consecutive patients (61.6±8.0 years) in whom at least one implant with a dehiscent implant surface of ≥⅔ of the implant length at the
labial side was placed between January 2006 and December 2009 were included (8). All implants were placed to support a maxillary overdenture. In short, these fully edentulous patients suffered from lack of retention and stability of the upper denture and had been referred to the Department of Oral and Maxillofacial Surgery (University Medical Centre Groningen, the Netherlands). The patients were at least 18 years of age, non-smoking, were capable of understanding and giving informed consent, were at least 1 year edentulous in the maxilla and mandible, had a sufficient volume of bone to place implants in the anterior maxillary and mandibular region, and had bone dimensions allowing for implant placement with sufficient primary stability. The study was approved by the Medical Ethical Committee of the University Medical Centre Groningen (ABR NL32503.042.11).

As mentioned above, patients for the present study were included if the exposed implant surface (measured with a pair of calipers during surgery) of at least one implant was ≥⅔ of the implant length (either 4 or 6 implants were placed in the maxilla, thus a maximum of six implants was placed with an exposed implant surface of ≥⅔ of the implant length).

The decision to set a dehiscence <⅔ of the labial implant surface as a cut-off point for this study is based on the following. Previously, it was proposed that a non-mobile implant demonstrating over 50% of vertical bone loss was a failure and has to be removed (9). However, treatment of peri-implantitis often converts a situation from unfavourable to favourable with respect to implant retention and arresting disease progression (10–12). Therefore, a criterion of >50% is too low to denote whether an implant is prone to failure. For this study we stated that a fixture should be characterized as prone to fail when ⅓ of the supporting peri-implant bone has been resorbed and there are signs of inflammation. This limit is arbitrary, but we presume that the potential to predictably place an implant with such a large dehiscence of the implant surface might be lower. The scoring was done by the surgeon (GMR). Implants of included patients were divided into three groups: ≥⅔ exposed surface at implant placement, <⅔ exposed surface at implant placement and no exposed surface at implant placement. The three groups of implants were compared to each other. After loading (T0), and one year (T1) and five years (T5) after overdenture placement, all patients were recalled.
Treatment procedure
All surgical procedures were performed by one experienced oral and maxillofacial surgeon (GMR). The prosthetic procedures were accomplished by three experienced prosthodontists. Manufacturing of the superstructure was done by a single experienced dental laboratory (8). In short, four or six dental implants with a length of at least 11 mm and a diameter of 4 mm were inserted in the maxillary anterior region (OsseoSpeed 4.0 S dental implants, Astra Tech AB, Mölndal, Sweden). The implants were placed at crestal bone level in predefined positions (positions 15, 13, 11, 21, 23, 25 in the six implants group; positions 13, 11, 21, 23 in the four implants group; Slot et al., 2013) with help of a surgical template in a two-stage procedure. All implants were inserted with a minimum of 2 mm bone thickness on the palatal side. All implants were inserted with adequate primary stability (insertion torque of 45 Ncm) (Figure 1).

Figure 1. The implants are placed with large dehiscences.

The dehiscence or fenestration of the implants was augmented with bone grafts harvested from the maxillary tuberosity region. The bone graft was harvested using chisels and shaped with forceps. The bone grafts were placed buccally of the implant in order to cover the surface and were fixed to the alveolar bone with titanium screws (Martin Medizin Technik, Germany) (diameter 1.5 mm) (Figure 2).
Figure 2. The dehiscences of the implants are covered with bone grafts harvested from the maxillary tuberosity region and fixed to the alveolar bone with titanium screws.

The “remaining” bone particles and the autogenous bone chips collected during implant bed preparation were used to fill the small gaps between the bone graft and the implant. After this, the reconstructed region was bucally covered with anorganic bovine bone (Bio-Oss®, Geistlich Pharma AG, Wolhusen, Switzerland) and a resorbable membrane (Bio-Gide®, Geistlich Pharma AG, Wolhusen, Switzerland). The mucoperiostal flap was replaced and wound closure was performed by using resorbable suture material Vicryl 4.0 (Ethicon, Norderstedt, Germany). Two weeks after implant placement, the patient was allowed to wear the removable dentures again after adjustment of the prostheses with a resilient lining material (Soft liner; GC Corporation, Tokyo, Japan). After a 3-months osseointegration period, second stage surgery was performed and the titanium screws were removed and healing abutments (Uni Healing Abutments, Astra Tech AB, Mölndal, Sweden) were placed (Figure 3).

The denture was adjusted in the area of the healing abutments and relined again with a resilient lining material. The design of the overdentures was full coverage of the alveolar process, but without palatal coverage in the maxilla. All implants were splinted with a bar.
Figure 3. Situation after a 3-months osseointegration period.

Outcome measures

Soft tissue conditions

For presence of plaque, the index according to Mombelli et al. (13) was used (score 0: no detection of plaque, score 1: plaque can be detected by running a probe across the smooth marginal surface of the abutment and implant, score 2: plaque can be seen by the naked eye, score 3: abundance amount of plaque).

The presence of calculus (score 1) or the absence of calculus (score 0) was scored.

To qualify the degree of peri-implant inflammation, the modified Löe & Silness index (14) was used (score 0: normal peri-implant mucosa, score 1: mild inflammation; slight change in colour, slight oedema, score 2: moderate inflammation; redness, oedema and glazing, score 3: severe inflammation; marked redness and oedema, ulceration).

For bleeding, the bleeding index according to Mombelli et al. (13) was used (score 0: no bleeding when using a periodontal probe, score 1: isolated bleeding spots visible, score 2: a confluent red line of blood along the mucosa margin, score 3: heavy or profuse bleeding).

Probing depth was measured at four sites of each implant (mesial, labial,
distal, and lingual) by using a manual periodontal probe (Williams Color-Coded Probe; Hu-Friedy, Chicago, Il, USA) after removal of the bar; the distance between the marginal border of the mucosa and the tip of the periodontal probe was scored as the probing depth. For each implant the deepest probing depth was recorded.

All parameters were scored at T0, T1 and T5.

**Implant survival**
Implant survival was defined as the percentage of implants initially placed that were still present and not mobile at follow-up. Lost implants were scored any time after placement. Mobile implants were scored by percussion after removal of the bar.

**Change of radiographic bone level**
Standardized intra-oral radiographs were taken at T0, T1 and T5. The intra-oral radiographs were taken according to a long-cone paralleling technique with an individualized X-ray holder (15). The digital images were analysed using computer software (Biomedical Engineering, University Medical Centre Groningen, the Netherlands) to perform linear measurements on digital radiographs. Reference line for bone level evaluation was the outer border of the neck of the implant. Mesial and distal bone changes in this region were considered as radiographic bone height change and were defined as the difference in bone height between the radiograph taken at T0, T1 and T5. The selected imaging technique showed an acceptable accuracy for peri-implant bone level measurements with an overall error of about 0.5 mm (16). Measuring was done by one observer (HJAM).

**Statistics**
Data collection was done by JWAS and analysis of the radiographs was done by HJAM. The worst score per implant of the clinical and radiographic parameters was used in the data analysis. The homogeneity between the implants with and without dehiscence was verified using the Pearson $X^2$ test. A $X^2$ value <0.05 was considered to represent a statistically significant difference. Because no statistical difference was observed between the three groups, the implant was used as the statistical unit. In each group, all variables were expressed in millimetres. Variables were not normally distributed. Descriptive statistics (e.g., median (interquartile range
(IQR) described as first quartile (Q1) - third quartile (Q3)) were used to characterize the subject population. The comparisons of the variables between the groups at T1 and T5 were performed using the Kruskal-Wallis test. A pairwise comparison was done if a significant difference was found. A P-value <0.05 was considered to represent a statistically significant difference. The data analysis was performed using Statistical Package for Social Sciences (version 22.0; SPSS Inc.: An IBM Company, IBM Corporation, Chicago, IL, USA).

Results
Patient characteristics are shown in Table 1. Forty implants were placed without dehiscence of the implant surface, 16 implants with a dehiscence <⅔ and 60 implants with a dehiscence ≥⅔. One patient died, not related to the implant therapy during the first year of evaluation (25 patients completed T1). Another patient died, again not related to the implant therapy, during the fourth year after implant. One patient was not able to visit for T5 because of severe dementia (23 patients completed T5). The mean age of the patients at implant placement was 61.6±8.0 years (range 46.5 – 80.1). During the surgical procedure there was no extensive bleeding at the donor site. Two patients had an antral perforation through the maxillary sinuses after harvesting the tuberosity bone. The wound was primary closed. Healing was uneventful. No objective signs of sinusitis were encountered during the evaluation period.

Wound healing after surgery was undisturbed with the exception of one patient with a slightly disturbed bone healing because of a small bone sequester. After removal of the bone sequester the wound healing was undisturbed.

Soft tissue conditions
No significant change in probing depth was seen between the three groups at T1 and T5 (Table 2). Mean scores of the indices for plaque, calculus, gingiva, and bleeding were very low too and did not change with time (Table 1).
Table 1. Characteristics of the subject population at the time of implant placement.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>T0</th>
<th>T1</th>
<th>T5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years ± SD)</td>
<td>61.6 ± 8.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender (%)</td>
<td>14 female (54%)</td>
<td>12 male (46%)</td>
<td></td>
</tr>
<tr>
<td>Plaque-score (median [IQR])</td>
<td>0.0 [0.0;0.0]</td>
<td>0.0 [0.0;0.0]</td>
<td>0.0 [0.0;1.0]</td>
</tr>
<tr>
<td>Gingiva-score (median [IQR])</td>
<td>0.0 [0.0;0.0]</td>
<td>0.0 [0.0;0.0]</td>
<td>0.0 [0.0;1.0]</td>
</tr>
<tr>
<td>Bleeding-score (median [IQR])</td>
<td>0.0 [0.0;1.0]</td>
<td>0.0 [0.0;1.0]</td>
<td>0.0 [0.0;1.0]</td>
</tr>
<tr>
<td>Calculus-score (median [IQR])</td>
<td>0.0 [0.0;0.0]</td>
<td>0.0 [0.0;0.0]</td>
<td>0.0 [0.0;0.0]</td>
</tr>
</tbody>
</table>

Differences between different T0, T1 and T5 were tested with the related-samples McNemar test (p<0.05). No significant differences were found. IQR: interquartile range.

Table 2. Median values and interquartile range (IQR) of radiographic bone loss in mm, probing depth in mm, and frequency distribution of bone loss 1 year and 5 years after placement of the overdenture of the implants placed with and without dehiscence.

<table>
<thead>
<tr>
<th></th>
<th>Group 1. No dehiscence (n=40)</th>
<th>Group 2. Dehiscence &lt;½ (n=16)</th>
<th>Group 3. Dehiscence ≥½ (n=60)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Loss of marginal bone between T0 and T1 in mm (median [IQR])</strong></td>
<td>-0.1 [-0.4;0.0]</td>
<td>0.0 [-0.2;0.0] *</td>
<td>-0.2 [-0.5;-0.1] *</td>
</tr>
<tr>
<td>0–0.5 mm</td>
<td>82.5%</td>
<td>100%</td>
<td>76.7%</td>
</tr>
<tr>
<td>&gt;0.5–1.0 mm</td>
<td>17.5%</td>
<td>0%</td>
<td>15.0%</td>
</tr>
<tr>
<td>&gt;1.0–1.5 mm</td>
<td>0%</td>
<td>5.0%</td>
<td>5.0%</td>
</tr>
<tr>
<td>&gt;1.5–2.0 mm</td>
<td>0%</td>
<td>1.7%</td>
<td>1.7%</td>
</tr>
<tr>
<td>&gt;2.0 mm</td>
<td>Missing data/implant loss</td>
<td>0%</td>
<td>1.7%</td>
</tr>
<tr>
<td><strong>Loss of marginal bone between T0 and T5 in mm (median [IQR])</strong></td>
<td>-0.4 [-1.0;– 0.0]</td>
<td>-0.2 [-0.9;0.0]</td>
<td>-0.5 [-0.8;-0.1]</td>
</tr>
<tr>
<td>0–0.5 mm</td>
<td>52.5%</td>
<td>62.5%</td>
<td>50.0%</td>
</tr>
<tr>
<td>&gt;0.5–1.0 mm</td>
<td>20.0%</td>
<td>6.3%</td>
<td>30.0%</td>
</tr>
<tr>
<td>&gt;1.0–1.5 mm</td>
<td>12.5%</td>
<td>12.5%</td>
<td>15.0%</td>
</tr>
<tr>
<td>&gt;1.5–2.0 mm</td>
<td>5.0%</td>
<td>6.3%</td>
<td>5.0%</td>
</tr>
<tr>
<td>&gt;2.0 mm</td>
<td>Missing data</td>
<td>5.0%</td>
<td>5.0%</td>
</tr>
<tr>
<td><strong>Change in probing depth between T0 and T1 (median [IQR])</strong></td>
<td>0.0 [-1.0 – 0.0] ¹</td>
<td>0.0 [-0.8 – 0.0] ¹</td>
<td>0.0 [-1.0 – 0.0] ¹</td>
</tr>
<tr>
<td><strong>Change in probing depth between T0 and T5 (median [IQR])</strong></td>
<td>0.0 [-1.0 – 1.0] ¹</td>
<td>0.0 [-0.3 – 1.3]</td>
<td>0.0 [0.0 – 1.0]</td>
</tr>
</tbody>
</table>

*A Kruskal-Wallis H test showed that there was a statistically significant difference in change of bone height between the different groups.

¹A negative change in probing depth reflects a less deep pocket.
IQR, interquartile range.
Implant survival
One implant placed with a ≥⅔ dehiscence was lost during the osseointegration period of 3 months. No other implants were lost during follow-up yielding a 1-year survival and 5-years survival of both 99.1%. Because a bar-supported overdenture could be made on the remaining five implants, there was no need to replace the implant.

Change of radiographic bone level
The amount of bone loss for all groups at T1 and T5 is shown in table 2 and figure 4. A Kruskal-Wallis H test showed that there was a statistically significant difference in change of bone height between the different groups (p = 0.044). Pairwise comparison revealed there was a significant difference between group 2 and 3 (p = 0.048) and no difference between group 1 and group 2 (p = 0.504) or group 3 (p = 0.554).

Thus, at T1, bone loss was higher, though clinical not relevant, for implants with a dehiscence ≥⅔ (-0.2 mm [-0.5;-0.1]) compared to implants with a dehiscence < ⅔ (0.0 mm [-0.2; 0.0]).

No significant differences in bone loss were seen at T5.
*Significant difference between groups 2 and 3 at T1 (p = 0.013).

Figure 4. Box and whisker plot of the difference in marginal bone height between T0 and T1 (1 year), and T0 and T5 (5 years) as measured on the intra-oral radiographs.

**Discussion**

Analysis of the data of this study revealed that placing implants with a dehiscence of the implant surface in the maxilla to support a maxillary overdenture does not result in worse per-implant health and implant survival under the condition that the implant is placed with primary stability and the dehiscence is covered with autologous bone, anorganic bovine bone and a resorbable membrane. This eliminates the need for a two surgical interventions (pre implant placement augmentation and abutment connection surgery) thus reducing morbidity and speeding up prosthodontic rehabilitation.
The incidence of complications, like sensory deficits in the lower lip and mental foramen area, among intraoral donor sites is more significant for the mandibular symphysis and the ramus area than the maxillary tuberosity (17,18). This observation is in line with the results of our study as the donor site (maxillary tuberosity) did not cause complications. Another advantage of choosing the tuberosity as the donor site is that harvesting of bone can be performed through the same incision as for the insertion of the implants.

The mean peri-implant probing depths and indices for plaque, calculus, gingiva and bleeding were very low at T1 and T5, and comparable to the scores reported in the literature (19,20). Also the implant survival rate was comparable to survival rates for implants placed in the maxilla (21). Because the measurements were done on intra-oral radiographs, we have to deal with a measurement error of 0.5 mm (16). The minor difference observed between the groups at T1 has no clinical relevance and had resolved at T5. Moreover, the radiographic bone loss observed (at T5) was small and well within the accepted limits (22).

**Conclusion**
Placing implants with a dehiscence ≥⅔ of the buccal implant surface with good initial stability combined with covering of the dehiscent surface with autologous bone, anorganic bone and a resorbable membrane is accompanied by a favourable 5-years peri-implant health.
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